Model ET-32-CM
Power Supply

# INSTRUCTION MANUAL

Model ET-32-CM

NJE CORPORATION

345 CARNEGIE AVENUE, KENILWORTH, N. J.

# N J E CORPORATION

# INSTRUCTION, MAINTENANCE AND REPAIR MANUAL

FOR MODEL ET-32-CM

N J E CORPORATION
345 Carnegie Avenue
Kenilworth, New Jersey

# SECTION I

## SPECIFICATIONS AND GENERAL DESCRIPTION

MODEL ET-32
or
MODEL E-32

**Input:** 208/220 ± 10% volts, 60 cycles per second, three phase, at approximately 1.3 KVA, 70% power factor, at full load.

**Outputs:** Continuously variable by front panel control from 16 to 40 volts DC at 0 to 18 amperes.

**Ripple:** 1% RMS maximum.

**Regulation:** Line, less than 0.5% for line voltage variations of 10%.

Load, less than 1%, no load to full load.

**Recovery Time:** Less than 75 milliseconds from ± 10% line or ± 50% load transients. (ET-series).
Zero for line transients of ± 10% or load transients of ± 25%. (Z-series).

## UNPACKING AND INSTALLATION

The complete power supply shipment consists of a small carton containing the thyratron tubes, and a large carton or crate containing the power supply. Both containers should be opened immediately upon receipt, and the contents inspected for shipping damage. When the unit leaves the factory it is thoroughly checked, both electrically and mechanically, and is warranted to be in perfect operating condition. However, we cannot guarantee that no damage will be incurred during shipment. Any evidence of mishandling, such as broken, deformed, or missing parts, should be brought to the attention of the shipping agency immediately, and a claim should be entered. Open the cabinet doors and inspect all components and wiring, both on the chassis and panel, as well as the mechanical condition of the housing.

After the unit has been placed in its operating location, unwrap the tube anode caps (inside the cabinet) and untie their leads. Then install the tubes in their clamps or sockets. Note that the tube, anode cap, and socket must be properly matched. Each set is identified by a small red letter, and it is extremely important for proper operation that the tubes be installed and connected in accordance with the letter code.

All connections are made at the terminal strip at the rear of the chassis. The AC input line is to be connected to the "AC" terminals at the left end of the strip. The output of the supply can be connected for either polarity, and can be floated as much as 500 volts (peak) above or below chassis ground. However, the most stable operation will be obtained when one of the two output terminals ("POS or "NEG") is connected to the chassis ground terminal (GND) either by a jumper, or through a 0.1 microfarad 600-volt capacitor.

To permit monitoring and regulating the load voltage without introducing an error due to the voltage drop in the interconnecting cables to the load, the input terminals of the correction amplifier have been brought out to the rear terminal strip ("POS SENS" and "NEG SENS"). These terminals must be connected through a separate "sensing" lead directly to the load terminals, observing the proper polarity. A 20-gauge stranded, shielded, insulated wire is recommended. (External insulation is required to permit connection for either polarity). While it is possible to jumper the sensing terminals directly to the "POS"and "NEG" output terminals at the terminal strip, this connection causes the load cables to be included as part of the external load, and the actual voltage at the remote load terminals will vary accordingly with changes in load current.

IMPORTANT: To avoid the possibility of damage in the event that the unit is put into use before these instructions are read, the sensing terminals are jumpered to the output terminals at the rear terminal strip prior to shipment from the factory. The jumper wires should be removed, and sensing leads should be connected to the load as indicated above, to obtain maximum stability of the load voltage.

Operating procedure is as follows:

1. Place AC and DC switches in OFF position.
2. Connect AC line to "AC" input terminals at rear of chassis.
3. Connect load terminals to "POS" and "NEG" output terminals, using insulated cables of appropriate gauge.
4. Connect a jumper from chassis ground terminal (GND) to "POS" or "NEG" output terminal [illegible] for proper load polarity. If load is to be floating, use [illegible] 1 mfd 600-volt capacitor instead of a jumper.
5. Connect sensing leads from "POS (+S)" terminal to positive load terminal and from "NEG (-S)" terminal to negative load terminal.
6. Throw AC switch to ON position.
7. Set output voltage control to minimum counterclockwise (minimum output) position.
8. When TIME DELAY OVER pilot lamp lights, throw DC switch to ON position.
9. Adjust the output voltage control to provide the required load voltage.

and Z-series power supplies are designed for use in a [illegible] providing a stable, reliable source of precision-regulated, [illegible] power. Conservative design of all circuit elements, self-[illegible] protection against brief overloads, well-planned mechanical [illegible]

[illegible]

[illegible] circuit which monitors the output voltage and maintains it [illegible] at a selected constant value despite variations in line [illegible] voltage or load current.

[illegible] supply differs from the corresponding EF series supply only [illegible] the output filter capacitance of the Z-series is considerably larger.

[illegible] transformer converts the AC line voltage to a suitable operating [illegible] the rectifier changes the AC voltage to pulsating DC voltage, and [illegible] filter greatly reduces the pulsations and furnishes a smooth DC [illegible] to the external load. This output voltage is affected by fluctuations in the AC line voltage and the DC load current. To maintain a [illegible] output voltage despite these variations, a feedback correction circuit is used. The input terminals of the correction amplifier are connected [illegible] through a potentiometer and a pair of sensing leads directly to the load. Minute variations in load voltage appear in magnified form as [illegible] at the output of the feedback amplifier. The amplifier output [illegible] a variable phase shift circuit. By shifting the phase (with respect [illegible] to the plate [illegible] voltage), the phase shift circuit determines the conduction angle of

; that is, it determines the portion of the AC cycle during
thyratrons conduct current.

voltage, the thyratron increases or decreases the power it
the load, accordingly raising or lowering the load voltage.
ate connection and adjustment of the amplifier and grid control
load voltage changes are applied inversely to the thyratron grids
produce equal but opposite changes in the supply output voltage.
in load voltage, regardless of the degree of error applied to
ever, the regulation from no-to-full load variations is maintained within the specified percentage.

is, it determines the portion of the AC cycle that ... ms conduct current.

... conduction earlier or later in the positive half-cycle of ... voltage, the thyratron increases or decreases the power ... the load, accordingly raising or lowering the load voltage ... e correction and adjustment of the amplifier and ... f voltage changes are applied inversely to the thyratron grid ... in load voltage. regardless of the degree of error amplification ... er, the regulation for zero-to-full load variation is ... fied within the specified percentage.

...ervised rectified output of the tubes is measured ...
...the cable type ZAMA-11-01, and delivered to the rectifier ...
...n an external cable connected to the POS and NEG output term...

...maintaining the voltage at the selected value despite line ...
...tions, a grid-control circuit is provided for each tube, and ...
...control circuits are operated by the output of a common correction ...

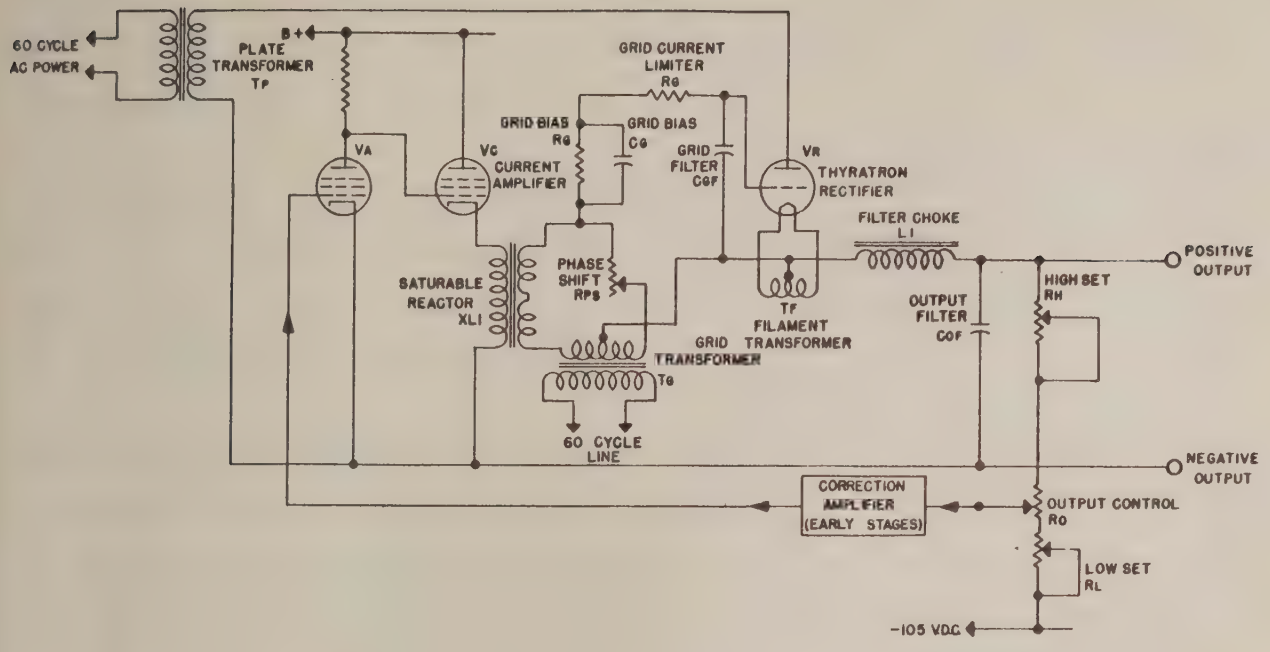
...CIRCUIT:

...of the grid control circuit is illustrated in Figure 1. The ...
...transformers TP and TG are energized by the same AC line, and ...
...ve secondary voltages are, consequently, in phase. Power ...
...of TG is a phase-shifting circuit consisting of variable ...
...saturable (variable) reactor XL1.

...this phase-shift circuit is taken from the center-tap of RC ...
...tion of RPS and XL1, and consists of a small ...
...h respect to the AC plate voltage wave is dependent upon ...
... and XL1. The parallel combination of resistor RC and ...
..., series with the grid provides a DC reference bias by ...
...tion, and the AC control signal from the phase-shift circuit ...
...ed upon this DC bias.

... of plate voltage on the tyratron, there is a relative-...
...tive grid voltage which will just prevent the ...

ducting. This value is known as the critical grid
is shown as a dotted curve in B of figure 1 for the entire
positive half-cycle of plate voltage. Should the grid voltage become
ve than the indicated critical value at any instant during the
f-cycle, the tube will fire at that instant and current thro
effects of the AC signal, the DC (grid rectification) bias
d sufficiently negative to maintain the tube in a conducting
dition. When the AC signal voltage is superposed on the DC
resultant bias fluctuates above and below the nominal DC value,
in Figure 1B. At some point during the positive half-cycle of
, the voltage on the grid becomes less negative than the critical
lue at that point, and the tube fires. This instant is indi
where the positive-going bias voltage curve intersects the
voltage curve. The tube conducts current throughout the
the half-cycle, and is extinguished when the plate voltage
o. By shifting the phase of the AC grid control wave (with
s plate voltage wave), the instant of firing can be changed
ier or later in the cycle, causing the tube to conduct
r or lesser fraction of the half-cycle. Figure 1C shows
trol curve intersecting the critical grid voltage curve at
in the plate voltage half-cycle (point X). Comparison of
d 1C shows that shifting the AC grid control wave to the right
on angle (interval of conduction) of the tube. The


60 CYCLE
AC POWER
PLATE
TRANSFORMER
TP
B+
GRID CURRENT
LIMITER
RG
GRID BIAS
RG
GRID BIAS
CG
GRID
FILTER
CGF
VA
VC
CURRENT
AMPLIFIER
VR
THYRATRON
RECTIFIER
FILTER CHOKE
L1
POSITIVE
OUTPUT
PHASE
SHIFT
RPS
SATURABLE
REACTOR
XL1
HIGH SET
RH
OUTPUT
FILTER
COF
TF
FILAMENT
TRANSFORMER
GRID
TRANSFORMER
TG
60 CYCLE
LINE
NEGATIVE
OUTPUT
CORRECTION
AMPLIFIER
(EARLY STAGES)
OUTPUT CONTROL
RO
LOW SET
RL
-105 VDC

A.

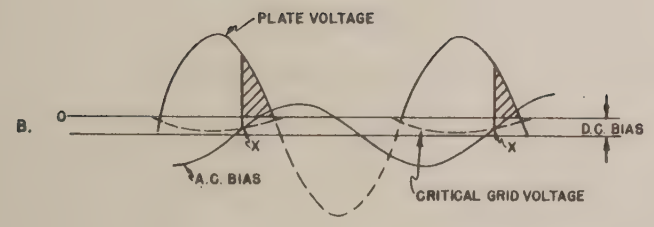


PLATE VOLTAGE
B.
0
X
X
D.C. BIAS
A.C. BIAS
CRITICAL GRID VOLTAGE

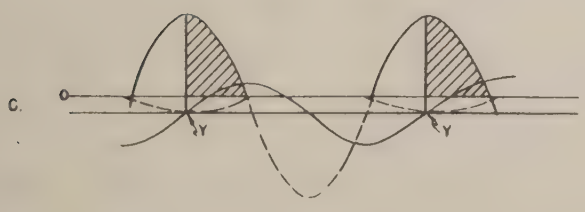

C.
0
Y
Y

FIG. 1

of the plate waves indicate the period during which the
s, and are representative of the relative amount of power
d to the load in each case.

from the diagrams that the greater the lag of the grid
respect to the plate wave, the smaller will be the conduction
his principle is used to automatically control the load voltage
lowing manner (refer to Figure 1A).

ge drop across the external load is connected (through a pair
al sensing leads) across a voltage divider RH-RO-RL. The input
rrection amplifier is determined by the setting of the movable
tiometer, RO which forms a part of the voltage divider.
ial of VA, the final stage of the correction amplifier,
he cathode current of the current amplifier tube VC, since the
A is direct-coupled to the control grid of VC. The cathode
e of RPS together determine the degree of phase-shift given to
control voltage at the thyratron grid, and since the current
grid voltage of VC determines the firing angle of the thyra-
justment of potentiometer RO, the firing angle can be adjusted
om zero to maximum. Since the firing angle determines the
during which the rectifier supplies energy to the filter, it

Grid Control Circuit --Cont'd.

applying a periodic output of the rectifier, an equilibrium is established at a particular value of output voltage.

When the load resistance decreases, the output voltage of the supply tends to decrease because of the greater current drain. This causes the control grid of the amplifier to go more positive, in turn increasing the current drawn by tube V1 through the control winding of the saturable reactor T1A. The increase in its saturation current, driving the anode of the thyratron V2 grid less negative by means of the bias winding, causes a greater portion of the positive half-cycle of plate voltage. The increased charging period compensates for the increased drain on the supply and the output voltage tends essentially to remain constant. A tendency of the output voltage to increase is counteracted in a similar manner by a decrease in the tube conduction interval.

According to theory alone then, if the correcting action results only from the "error" detected by monitoring the output, the compensation can never be complete, regardless of the amplifier gain. The compensating system is a closed loop, since an input voltage produces an output voltage change, which in turn is fed back to the input in such a way as to counteract the original change at the input. Should the "error" be reduced to zero, the compensation would disappear. This means only that an absolutely steady output can be maintained with a perfectly steady input, which is evidently untrue. Increases in the gain of the amplifier circuit permit it to operate equilibrium with less residual error, but a small error must always remain, in a true proportional regulator.

While the foregoing material outlines the functioning of a single thyratron rectifier, it can be applied without change to any one of the two rectifiers in the single-phase units, the three rectifiers in the three-phase half-wave units, or the six rectifiers in the six-phase star units. The plate and grid transformers in each supply are properly phased so that each rectifier conducts in its turn, and the repetitive sequence of current pulses is smoothed and filtered by the common multi-input filter at the output of the supply. The correction amplifier in the supply simultaneously controls the degree of phase shift of the AC grid voltage wave on all rectifiers, but the A-C wave itself is generated at each grid in proper sequence to control all phases of the output.

To assure equal consumption and proper distribution between the rectifiers the resistance member of the RC phase-shift circuit is adjustable. By observing the output waveform on an oscilloscope connected to the positive end of the output filter choke, and adjusting these resistances to produce identical consecutive voltage waveforms on an oscilloscope circles of at least two line cycles, equal sharing of the load can be achieved. This adjustment is also used to shift the regulated range of the DC output, so as to coincide with the rated output voltage range.

The correction amplifier (see equipment schematic at the back of this manual), has an integral DC power supply consisting of a power transformer T101, full-wave center-tapped rectifier V-7(1) and a capacity filter C101. A zener-rectifier V107 establishes a regulated reference voltage for the system, maintained by glow tube V-108. Glow tube V108 provides an alternate stable reference potential for the regulated amplifier V101. The output

potentiometer R1 controls the quiescent output voltage of the
[illegible] of the input comparison
[illegible] R107 and current
[illegible] control winding of the
saturable reactor in the thyratron grid circuit. Capacitors C-106, C-108,
[illegible], and resistors R108, R104 and potentiometer R116 constitute a
[illegible]
[illegible] from normally positive dc voltage [illegible]
load oscillation. [illegible] circuit oscillation at the desired
[illegible] preliminary adjustment of the supply, to provide stable operation
[illegible] rated conditions of operation. Normally potentiometer R116
requires no further adjustment once their proper setting has been estab-
[illegible]; it requires retrimming when tubes or other circuit components
are changed.

## SECTION III

## MAINTENANCE

### PREVENTIVE MAINTENANCE

To establish a preventive maintenance program it is suggested that the equipment be tested shortly after it is put into operation for the first time, when it is most likely to be in good operating condition, and that the results of these tests be recorded for a reference for comparison with subsequent periodic tests. By keeping a running log of periodic results, it will be possible to detect any major change in operating characteristics, pointing to trouble. Failure of the equipment can be a defective component, but also the slow deterioration in performance which is a natural result of component aging.

A set of standard operating conditions should be selected, and the equipment should be periodically tested, both statically and dynamically, under these conditions. For a static test, a pre-determined load should be connected across the output terminals of the supply, and the unit adjusted for a selected output voltage across the load. A thorough check of the equipment should then be made with regard to ripple and output voltage stability, checking for slow periodic fluctuations and random erratic variations. A dynamic test should then be made by observing the output voltage on an oscilloscope as the pre-determined load is connected and disconnected, recharging the ripple, and measuring the regulation. Making the above tests on a regular monthly or semi-monthly basis, and recording the results in log form, will only be keep simplicity and accuracy in a minimum.

A visual check of the unit should also be made at the time that these

minals, uneven glow in the rectifier tubes, blown capacitor
t down the unit and take hot spot temperature measurements at
local overheating of components. Remove dust, dirt, and other
terial that have accumulated in the equipment.

shut down the equipment before cleaning
it or touching it internally for any reason!

s should be tested every 1000 hours, and replaced at the first
terioration. It is recommended that all vacuum tubes be replaced
ally after 2500 to 3000 hours of operation. Thyratrons carry a
er's warranty for 3000 hours of operation, and automatic replace-
se tubes at the end of 10,000 hours is advisable. This points
sibility of recording equipment hours of operation in the log
ntervals, or oftener if the operating schedule is erratic.

connections should be minutely inspected. Switches, potentio-
, sticking, binding, pitting, poor contact, or evidence of malfunction.
sion should be removed, and the surface painted or lubricated

CORRECTIVE MAINTENANCE:

When the action of the unit in operation, or the maintenance procedures indicate that the equipment is not regulating properly, a check of the error amplifier should be made. Tube (possibly another amplifier should be substituted for the one in question) and a measurement of the regulation made. If the amplifier is not at fault, then check the thyratron grid circuit, filter choke, and transformers, in that order.

Observation of the input voltage to the rectifier, on a cathode ray oscilloscope if possible, will be the most rapid means of locating the defective component. Check for irregularity in this voltage, and for incorrectness in the thyratrons as a means of eliminating the irregularity.

Excessive ripple may be the result of defective filter capacitors, blown fuses, or failure of one of the thyratrons to conduct. Again an oscilloscope check of the rectified output is recommended as the most rapid means of locating the source of trouble. Failure of one or more phases of the rectified output is easily detected, and correcting of the defective item can quickly be made by observation of the waveform at the input to the filter.

GRID CONTROL CIRCUIT ADJUSTMENTS:

1. Single-Phase Units

The two thyratron rectifiers are controlled by a pulse-shifting network consisting of an adjustable resistance R201, and a saturable reactor T201. The network is energized from one of the three-phase winding on transformer T7 and its pulse-shifted output is coupled in push-pull to the two thyratron grids by transformer T202. The

the control amplifier is swung through its full range. The output [illegible] control winding of the saturable reactor X1201 will [illegible] thereby raising the DC output voltage. Similarly, an increase in the value of the resistance leg R201 will advance the phase and raise the output voltage. Calibration of the [illegible] is accomplished as follows:

a. Remove the current amplifier tube V108 (type 6AQ5) from its socket. This causes the current in the control winding of the saturable reactor to drop to zero.

b. Adjust phase-shift resistor R201 to a value which gives slightly less than minimum [illegible] voltage, with no external load connected to the [illegible] and the line voltage at its nominal value.

c. Insert V108 in its socket and [illegible] between its grid and cathode. This will saturate the tube, drawing maximum current through the control winding of the saturable reactor. This should raise the output voltage [illegible]. If it does not, a defective

component or connection is indicated. After making the check, remove the grid-cathode jumper from V108.

c. Rotate the OUTPUT control R1 to its full clockwise position, and adjust the HIGH SET control R2 to produce a DC output voltage somewhat above the rated maximum. Connect an external load of a value sufficient to draw the maximum rated current, and readjust R118 to provide a load voltage somewhat slightly higher than the rated maximum. (Note: If the load is to be located at a considerable distance from the supply, the maximum output voltage should be set high enough to allow for line resistance drop in the interconnecting cable.)

d. Disconnect the external load, and rotate the OUTPUT control to its maximum counterclockwise position. Adjust the LOW SET Control R3 so as to produce a DC output voltage slightly less than the rated maximum value. If this is not attainable, adjust the phase-shift resistor R201 to permit reaching the required output value with R3.

e. As a final check, make certain that OUTPUT control R1 still provides greater than maximum rated output at full clockwise position, at full load, with line voltage at the lowest rated value.

3. Transistor Units

a. Connect a suitable load and a DC voltmeter across the output terminals.

is controlled through a separate phase-shift network. In units employing six phase half-wave rectification, each pair of thyratrons is controlled by a single phase-shift circuit whose output is transformer-coupled to the two thyratron grids in push-pull. In both cases, all phase shift circuits are controlled by one common correction amplifier.

Adjustment of the phase shift network is identical to that outlined above for single-phase units, except that equal adjustments must be made on all three phase shift resistors. This is easily accomplished by connecting an oscilloscope from the input terminal of filter choke L1 to the negative output terminal, and adjusting the sweep to show at least six half-wave loops of the rectified output. By observing the pattern while adjusting the three phase-shift resistors, equal amplitudes can be obtained for the outputs from the individual rectifiers, to assure equal sharing of the load. This adjustment should always be made as a final check after any readjustment of the phase-shift circuits.

5. Oscillation Suppressor Circuit Adjustment

Capacitors C105, C109, C106 and resistors R105 and R116 constitute a frequency and phase-shift compensating circuit which prevents feedback around the loop from become positive and causing the system to break into oscillation. While this type of oscillation is not desirable, it is encountered frequently enough to warrant inclusion of the compensating circuit as a standard item. Should the power supply exhibit a tendency to oscillate, after maintenance adjustments or a tube replacement, adjust potentiometer R114 to a position which causes the oscillation to disappear.

NOTE: —— DESIGNATES #20 WIRE
—— DESIGNATES #20 SHIELDED WIRE

S1 AC ON OFF

I1 GREEN

K1 TIMER

"TIME DELAY OVER" I2 AMBER

"OFF" "ON" S2 DC

I3 RED

P1 MATES WITH J101 (CHASSIS REAR APRON) SEE DWG NO. S-AMP(-ET)

"OUTPUT VOLTAGE CONTROL"

R3 100 2W

HI-SET

20K 2W

CONTROL PANEL

LO SET

R2 2K 2W

OFF

M1 SEE NOTE 1

M2 SEE NOTE 1

POS. OUTPUT

TUBE SHELF

V1-3 = EL 6 J

V3

C5 .001 MFD 600V

GC 3 NJE # ET12

V2

C4 .001 MFD 600V

GC 2 NJE # ET12

V1

C3 .001 MFD 600V

GC 1 NJE # ET12

P2 MATES WITH J102 (AMPLIFIER) SEE DWG NO.

NJE # T2 ET/F5

BASE

F4A 6A F4B 6A F4C 6A

TB 2

K2

T1 # ET32

208-220 V ± 10% 50 ~ 3 ϕ 4 WIRE INPUT

FIC 8A FIB 8A FIA 8A

#14

P1

WIRE SIZE
FIU1-3 - #10 WIRE
—— : #12 WIRE
- - - : #20 WIRE

NOTES
1-OPTIONAL, USED IN CM & -2M MODELS ONLY.

F2 25A

L1 NJE # L1-ET32

L2 NJE # L2-ET32

1 FUSE

C1 10X5000 MFD 50 V DC

C2 3X5000 MFD 50 V DC

R 4 watt 2 x 10 Ω 100 W

IN SERIES

POS. SENSING

POS. OUTPUT

GROUND

NEG. OUTPUT

NEG. SENSING

N. J. ELECTRONICS CORP.
CONTROL PANEL & RECTIFIER UNIT SCHEMATIC
S-ET-32-C 1

T101
HUE
KET

YELLOW
YEL-GN
RED
BLK.
ORANGE
BLK
RED
GRN.
GRN.
A
B
V101
6X4
V102
6.4
C101
20 MFD
450V
C102
20MFD
450V
R101
NN
3K 10W
V103
0A2
15
2.47
R103
1M 1W
R
150K,
1W
R
.5
1W
V
6.3
4.2
C107
1000 MMF
500V
V107
6U8
R108
1M
C110
.05MFD
300V
COMPRESS
R112
3M 1W
C111
.05MFD
300V
COMPRESS
R113
1M 1W
R114
1M 1/2W
5.1
2.4
R107
NN
7.5K 10W
C108
.1MFD 400V
MYLAR
R115
100K 1/2W
#20
#20
J101
1
3
5
7
10
2
4
6
8
9
MATES WITH P2
(TUBE SHELF)

NOTES- IF #20 WIRE FOR FILAMENTS
USE #24 WIRE FOR ALL OTHER WIRING
UNLESS OTHERWISE SPECIFIED.

FOR POWER SUPPLY SEE A-H1-ET

| | | |
|---|---|---|
| MATERIAL | | |
| FINISH | | |
| ALL DIMENSIONS IN INCHES | UNLESS OTHERWISE SPECIFIED | |
| DECIMALS ± .005 | | |
| FRACTIONS ± 1/64 | | |
| ANGLES ± 1/2° | | |
| DRAWN | APPROVED | |
| DATE 5-9-58 | | |

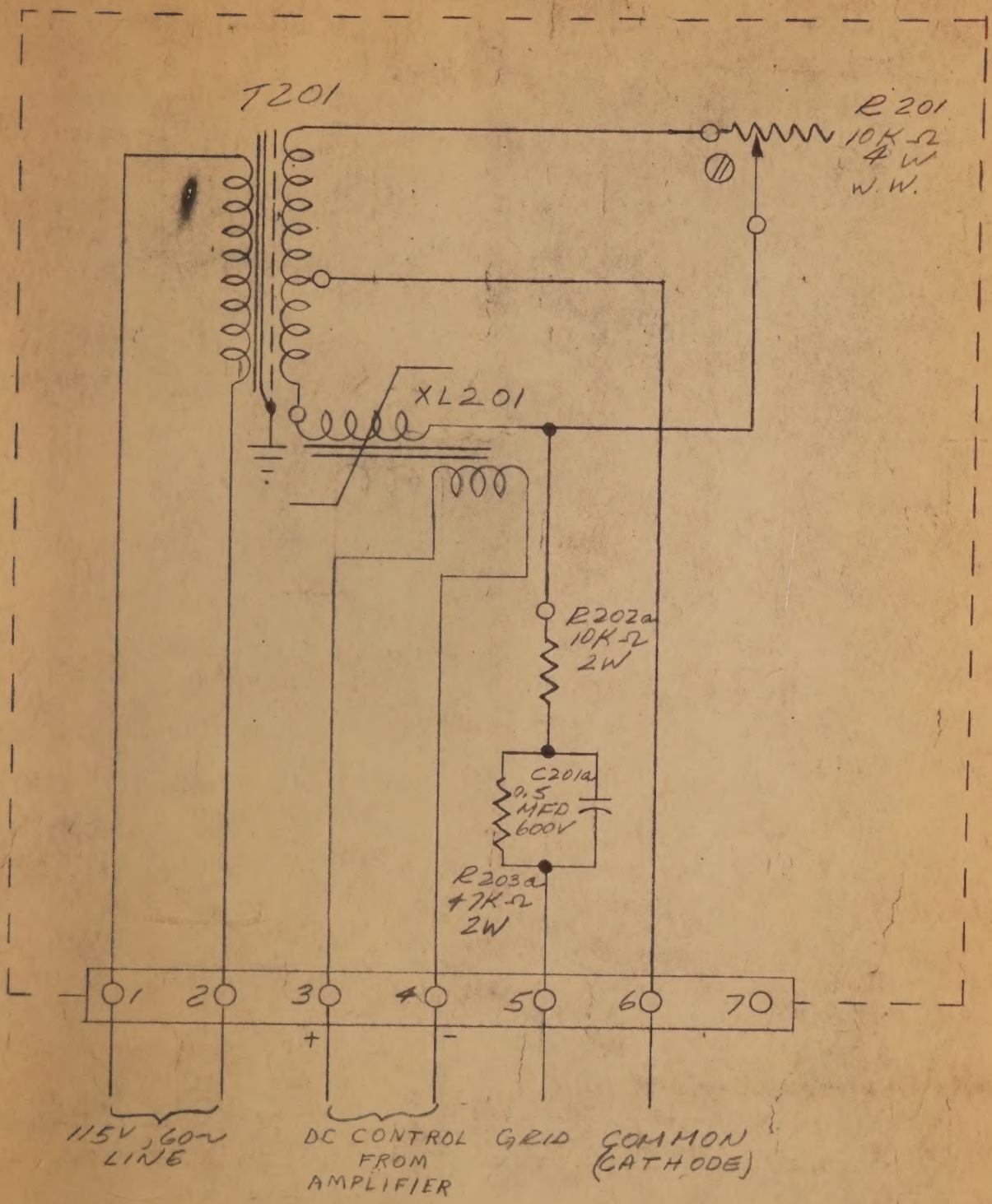
N. J. ELECTRONICS CORP.
845 CARNEGIE AVE. KENILWORTH, N. J.

STANDARD ET AMPLIFIER
SCHEMATIC
(FOR VOLTAGE REGULATOR)

S-A1-ET 5

SHEET

GC-ET/2


T201
R201
10K Ω
4 W
W.W.
XL201
R202a
10K Ω
2W
C201a
0.5
MFD
600V
R203a
47K Ω
2W
1
2
3
4
5
6
7
+
-
115V, 60~
LINE
DC CONTROL
FROM
AMPLIFIER
GRID
COMMON
(CATHODE)

| OMPONENTS - MANUFACTURED BY N.J.E. | |
|---|---|
| T201 | GRID - XFR N.J.E. # T201 - ET |
| L201 | GRID CONTROL REACTOR NJE # XL201-ET |

TE:
S GRID CONTROL CIRCUIT APPLIES
3 ϕ H.W. (3 REQ'D)

MATERIAL

FINISH

ALL DIMENSIONS IN INCHES
DECIMALS ± .005 } UNLESS
FRACTIONS ± 1/64 } OTHERWISE
ANGLES ± 1/2° } SPECIFIED

N. J. ELECTRONICS CORP.
345 CORNELIA AVE. KEARNY 32 N. J.

THYRATRON GRID CONTROL CIRCUIT
N.J.E. MOD. # GC-ET/2

DESIGNER
DRAWN BY DRI
DATE 6-26-56
APPROVED BY
CHECKED
SCALE —
DWG. NO. S-GC-ET/2
ISSUE
SHEET OF SHEETS

OUR WARRANTY: N J E Corp. warrants each power supply manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replacing any defective parts thereof, except tubes and fuses in "standard-grade" models. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and which upon our examination is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.